1/11

DRAM0
DRAM1
DRAM2
DRAM3
DRAM4

HUB

DRAM5
DRAM6
DRAM7
DRAM8

Fig 1

Title: METHOD FOR MEASURING AND
COMPENSATING SKEWS OF DATA
TRANSMISSION LINE
Applicant(s): Paul George Lindt
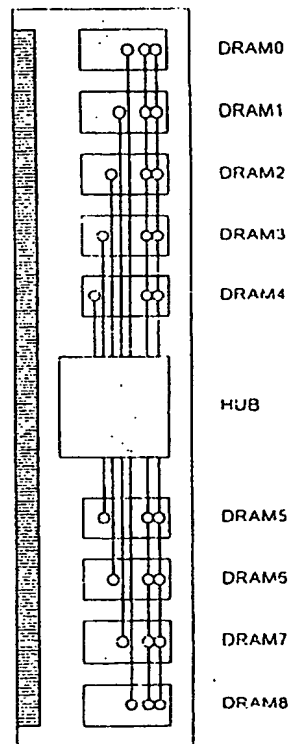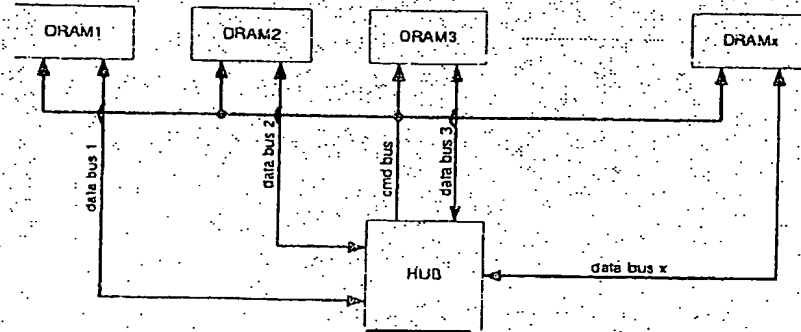Atty. Docket No.: 1406/142/2

2/11

Fig 2

3/11
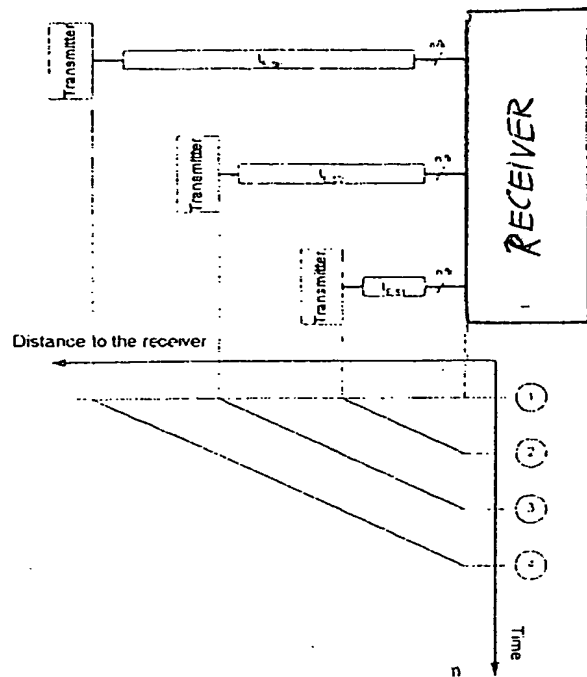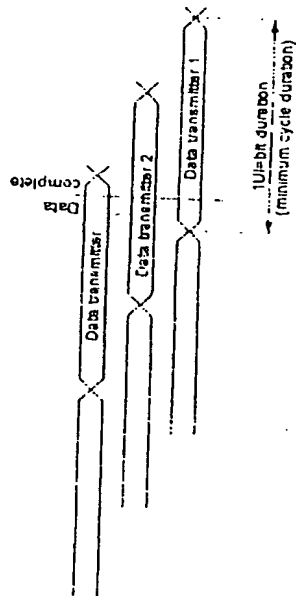

Fig 3

4/11

Figure 3. Danger to data integrity resulting from delay time differences

Fig. 4

5/11

Fig. 5

$Fig6$

$\dfrac{7}{11}$

Start S0

HUB power up S1

send cmd to
DRAMs to start
transmission of
MV with i=0 S2

measure skew on
back data bus S3

compensate skew S4

ready for data
transmission S5

Stop S6

Fig 7

$\frac{8}{11}$

skew measurement
procedure (S3)


```
        ( Start skew measurement )  S3-0

S3-1   [ enable clock and      variables:
         data recovery ]        t=0, skew=0, insert=0
              | clk clocked

S3-2   [ compare               RV: Reference Vector
         RV with MV ]          MV: Measurement Vector
              |
           < match >  S3-3 ─── yes ───┐
              | e                      |
S3-4   [ insert=insert+2 ]    tracks the number    [ i=i+1 ]  S3-8
              |                of inserted UIs         |
S3-5   [ delay lane by 2 UI ]  delays data line    [ send cmd(i) ]  S3-9
              |                by 2 UIs                |
S3-6   [ i=i+1 ]              changes RV          [ compare
              |                                     RV with MV ]  S3-10
S3-7   [ send cmd(i) ]         changes MV             |
              |                                    < match >  S3-11 ── yes ──┐
              └──────────                              | o                    |
                                                       | c   S3-12            |  S3-13
                                          [ skew=2*insert ]        [ skew=insert ]
                                                       |                      |
                                          [ remove inserted delays ]  S3-14
                                                       |
                                          [ skew
                                            measurement
                                            complete ]  S3-15
                                                       |
                                                  ( stop )
```
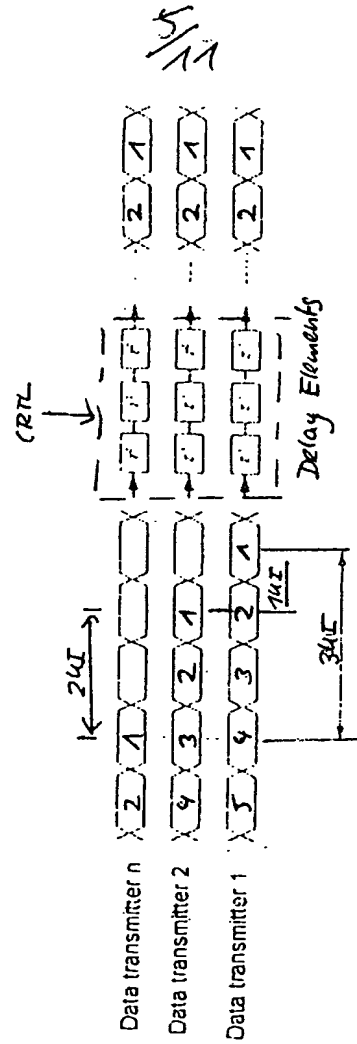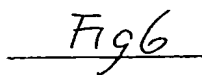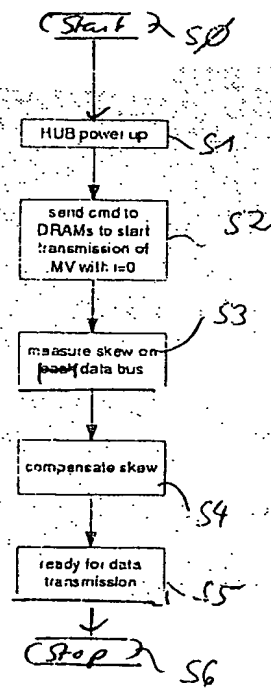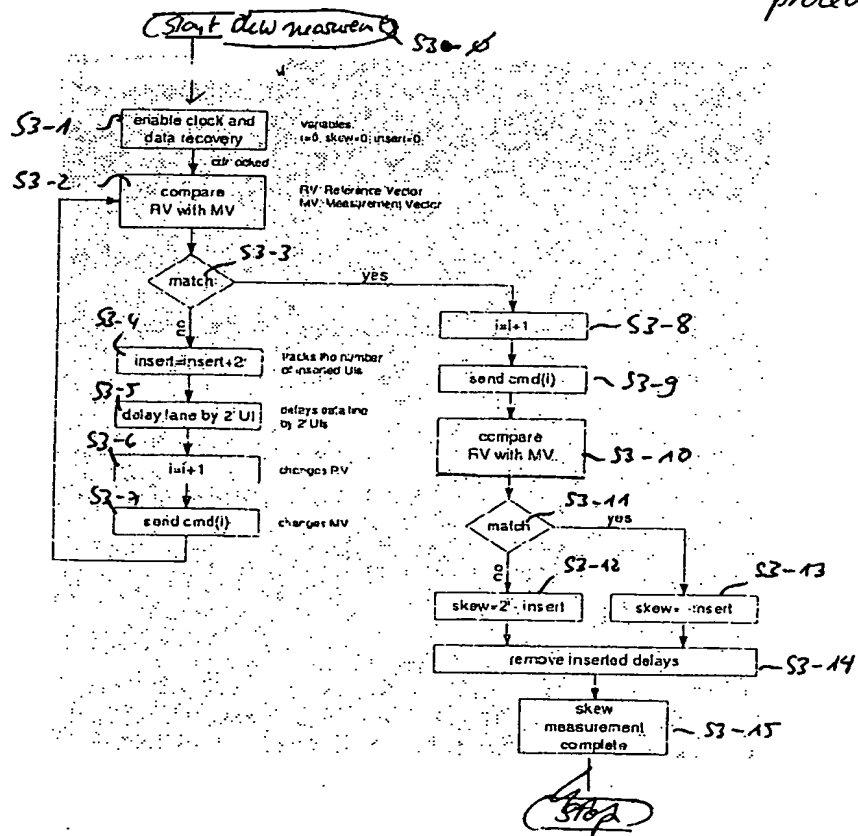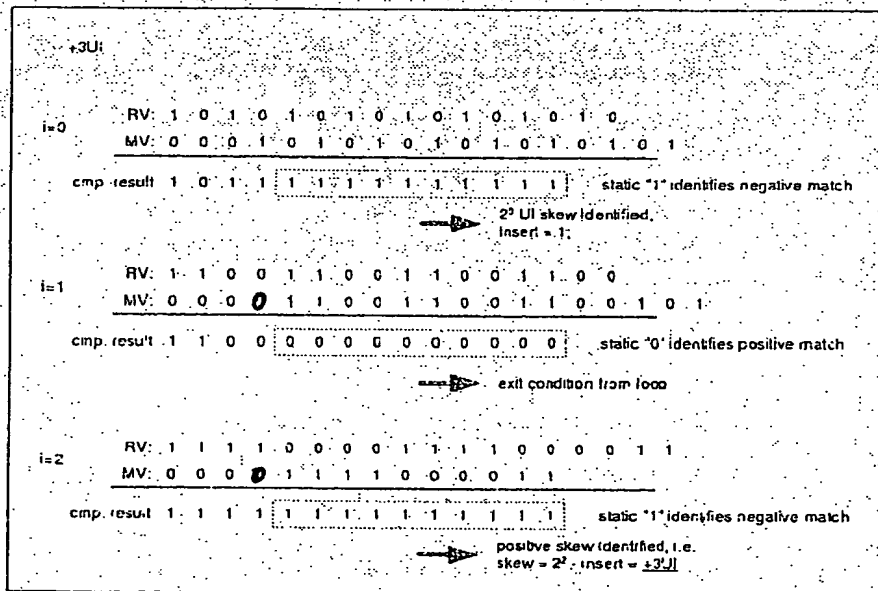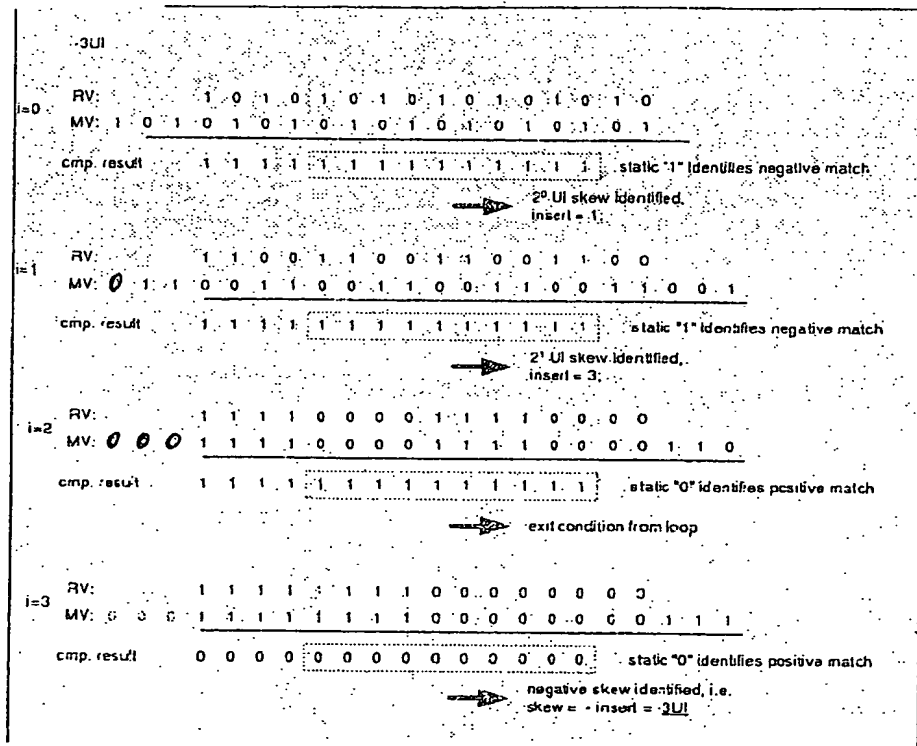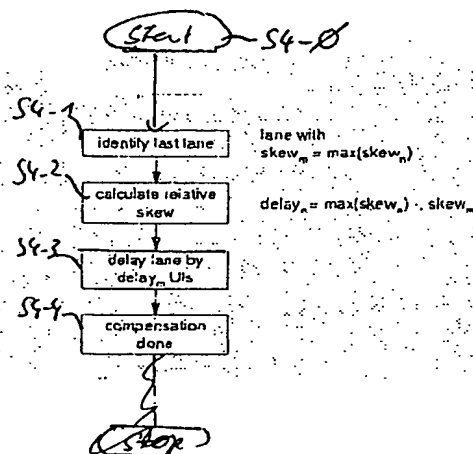
Fig. 8

$\frac{9}{11}$

Fig 9a

Fig 9b

Fig 9c

Fig. 9

10/11

-3UI

i=0 RV: 1 0 1 0 1 0 1 0 1 0 1 0 1 0
     MV: 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1

     cmp. result   1 1 1 1 1 1 1 1 1 1 1 1 1   static "1" identifies negative match

Fig 10a

                                    2⁰ UI skew identified.
                                    insert = 1;

i=1 RV: 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0
     MV: 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1

     cmp. result   1 1 1 1 1 1 1 1 1 1 1 1 1 1   static "1" identifies negative match

Fig 10b

                                    2¹ UI skew identified.
                                    insert = 3;

i=2 RV: 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0
     MV: 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 0 1 1 0

     cmp. result   1 1 1 1 1 1 1 1 1 1 1 1 1 1   static "0" identifies positive match

Fig 10c

                                    exit condition from loop

i=3 RV: 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0
     MV: 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 1 1

     cmp. result   0 0 0 0 0 0 0 0 0 0 0 0 0 0   static "0" identifies positive match

Fig 10d

                                    negative skew identified, i.e.
                                    skew = - insert = -3UI

Fig. 10

$$\frac{11}{11}$$

Start — S4-0

Skew
compensation
procedure
(Step S4)

S4-1
identify last lane

lane with
$skew_m = max(skew_n)$

S4-2
calculate relative
skew

$delay_n = max(skew_n) - skew_m$

S4-3
delay lane by
$delay_m$ UIs

S4-4
compensation
done

Stop

Fig. 11